GLOSSARY

Alpha particle. A particle consisting of two protons and two *neutrons*, given off by the *decay* of many elements, including *uranium*, *plutonium*, and *radon*. Alpha particles cannot penetrate a sheet of paper. However, alpha emitting *isotopes* in the body can be very damaging.

Americium. A manmade *transuranic element*; the next element following *plutonium* on the periodic table.

Atmospheric testing. The aboveground explosion of a nuclear device in order to test it or its effects.

Atom. The basic component of all matter. The atom is the smallest part of an element that has all of the chemical properties of that element. Atoms consist of a *nucleus* of protons and *neutrons* surrounded by electrons.

Atomic Energy Commission (AEC). The AEC was created by the United States Congress in 1946 as the civilian agency responsible for the production of nuclear weapons. The AEC also researched and regulated atomic energy. Its weapons production and research activities were given to the *Energy Research and Development Administration* in 1975, while its regulatory responsibility was given to the new Nuclear Regulatory Commission.

B Plant. The second *chemical separation* "*canyon*" built at the *Hanford Site* in Washington State for the *Manhattan Project* during World War II, the B plant was built between 1942 and 1945 and was used for *plutonium* recovery until 1956. Since then, it has had other uses. The code name "B" is arbitrary.

B Reactor. The world's first full-scale *plutonium production reactor*, the B reactor is located at the *Hanford Site* in Washington State. Construction on this reactor for the *Manhattan Project* started in 1943 and was completed in 1944. B reactor operated from 1944 to 1946 then from 1948 to 1968. The code name "B" is arbitrary.

Beta particle. A particle emitted in the *radioactive decay* of many *radionuclides*. A beta particle is identical with an electron. It has a short range in air and a low ability to penetrate other materials.

Calcine. A process that uses heat to reduce liquid *high-level waste* into a dry, powdery form. Also the powdered waste that results from this process.

Calutron. A device that uses an electromagnetic process to *enrich uranium*. Calutrons at the *Y-12 Plant* in *Oak Ridge* were used to *enrich uranium* for the *Manhattan Project*.

Canyon. A vernacular term for a *chemical separations plant*, inspired by the plant's long, high, narrow structure. Not all chemical separations plants are canyons.

Cesium. An element chemically similar to calcium. *Isotope* cesium-137 is one of the most important *fission products*, with a *half-life* of about 30 years.

Chain reaction. A self-sustaining series of nuclear *fission* reactions, *when neutrons* liberated by fission cause more fission. Chain reactions are essential to the functioning of *nuclear reactors* and weapons.

Chemical separation. Also known as *reprocessing;* a process for extracting *uranium* and *plutonium* from dissolved *irradiated targets and spent nuclear fuel* and *irradiated targets*. The *fission products* that are left behind are *high level wastes*.

Cladding. The outer layer of metal over the *fissile* material of a nuclear *fuel element*. Cladding on the Department of Energy's *spent fuel* is usually aluminum or zirconium.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A Federal law, enacted in 1980, that governs the cleanup of hazardous, toxic, and radioactive substances. The Act and its amendments created a trust fund, commonly known as *Superfund*, to finance the investigation and cleanup of abandoned and uncontrolled hazardous waste sites.

Criticality. A term describing the conditions necessary for a sustained nuclear *chain reaction.*

Curie. The amount of radioactivity in 1 gram of the *isotope* radium 226. One curie is 37 billion *radioactive decays* per second.

Decay (radioactive). Spontaneous disintegration of the *nucleus* of an unstable *atom*, resulting in the emission of particles and energy.

Decay product. The *isotope* that results from the *decay* of an unstable *atom*.

Decommissioning. Retirement of a nuclear facility, including *decontamination* and/or dismantlement.

Decontamination. Removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process.

Defense Waste Processing Facility. A *high-level-waste vitrification* plant built at the *Savannah River Site*.

Department of Energy (DOE). The cabinet-level U.S. Government agency responsible for nuclear weapons production and energy research and the cleanup of hazardous and radioactive waste at its sites. It was created from the *Energy Research and Development Administration* and other Federal Government functions in 1977.

Depleted uranium. *Uranium* that, through the process of *enrichment*, has been stripped of most of the *uranium 235* it once contained, so that it has more *uranium 238* than *natural uranium*. It is used in some parts of nuclear weapons and as a raw material for *plutonium* production.

Deuterium. A naturally occurring *isotope* of *hydrogen*. Deuterium is lighter than *tritium*, but twice as heavy as ordinary hydrogen. Deuterium is most often found in the form of *heavy water.*

Dose. As used here, a specific amount of *ionizing radiation* or toxic substance absorbed by a living being.

Dry cask storage. The storage of *spent nuclear fuel* without keeping it immersed in water.

Energy Research and Development Administration (ERDA). The agency created in 1975 to take over the weapons production and research responsibilities of the *Atomic Energy Commission*. ERDA was transformed, along with other Federal Government functions, into the cabinet-level *Department of Energy* in 1977.

Enrichment. The process of separating the *isotopes* of *uranium* from each other. Other elements can also be enriched. In the United States this is done using the *gaseous diffusion* process.

Enriched uranium. *Uranium* that, as a result of the process of *enrichment*, has more *uranium 235* than natural uranium.

Environmental contamination. The release into the environment of *radioactive*, hazardous and toxic materials.

Environmental Management. An Office of the *Department of Energy* that was created in 1989 to oversee the Department's waste management and environmental cleanup efforts. Originally called the Office of Environmental Restoration and Waste Management, it was renamed in 1993. Often abbreviated EM.

Environmental Protection Agency. A Federal agency responsible for enforcing environmental laws, including the *Resource Conservation and Recovery Act*; the *Comprehensive Environmental Response, Compensation and Liability Act*; and the *Toxic Substances Control Act*. The Environmental Protection Agency was established in 1970.

Epidemiology. The branch of medicine that studies the sources, distribution, and determinants of diseases and injuries in human populations.

Evaporation pond. A pond constructed to hold liquid *radioactive* wastes so that the water can evaporate away, leaving behind the dissolved and suspended radioactive material.

Fernald plant. The *uranium* foundry built in the early 1950s to supply uranium for nuclear weapons production. Located near Fernald, Ohio, 20 miles northwest of Cincinnati. Known as the Feed Materials Production Center during the Cold War and now officially referred to as the Fernald Environmental Management Project.

Final assembly. The task of assembling a nuclear weapon from its component parts and sub-assemblies. This is done at the *Pantex Plant*.

Fissile. Capable of being split by a low-energy *neutron*. The most common fissile *isotopes* are *uranium 235* and *plutonium 239.*

Fission. The splitting or breaking apart of the *nucleus* of a heavy *atom* like *uranium* or *plutonium*, usually caused by the absorption of a *neutron*. Large amounts of energy and one or more *neutrons* are released when an atom fissions.

Fission products. The large variety of smaller *atoms*, including *cesium* and *strontium*, left over by the splitting of *uranium* and *plutonium*. Most of these atoms are *radioactive*, and they *decay* into other *isotopes*. There are more than 200 isotopes of 35 elements in this category. Most of the fission products in the United States are found in *spent nuclear fuel* and *high-level waste.*

Formerly Utilized Sites Remedial Action Program. A program to clean up privately owned facilities that were contaminated as a result of past nuclear weapons research and production. Many of these facilities did work for the *Manhattan Project*. Commonly referred to by its acronym, FUSRAP.

Fuel (nuclear). *Natural* or *enriched uranium* that sustains the *fission chain reaction* in a *nuclear reactor*. Also used to refer to the entire *fuel element*, including structural materials such as *cladding*.

Fuel element. Nuclear reactor fuel including both the *fissile* and structural materials, such as *cladding*, typically in the shape of a long cylinder.

Fusion. The process whereby the *nuclei* of lighter elements, especially the *isotopes* of *hydrogen* (*deuterium* and *tritium*) combine to form the *nucleus* of a heavier element with the release of substantial amounts of energy.

Gamma radiation. High-energy electromagnetic *radiation* emitted in the *radioactive decay* of many *radionuclides.* Gamma rays are similar to X-rays. They are highly penetrating.

Gaseous diffusion. The process used to make *enriched uranium* in the United States.

Geologic repository. A place to dispose of *radioactive* waste deep beneath the earth's surface.

Glovebox. A sealed box used to handle some *radioactive* materials with gloves attached to the wall. Often filled with an *inert gas* and fitted with a filtered ventilation system.

Half-life. The time it takes for one-half of any given number of unstable *atoms* to *decay*. Each *isotope* has its own characteristic half life. They range from small fractions of a second to billions of years. A general "rule of thumb" in health physics is that the hazardous period for a given isotope is 10 half-lives.

Hanford Site. A 570-square-mile Federal government-owned reservation in the desert of southeast Washington State. Established in 1943 as part of the *Manhattan Project*, the Hanford Site's chief mission has been the production of *plutonium* for use in nuclear weapons. Hanford is home to nine *production reactors* and four *chemical separation plants*.

Health physics. The science of *radiation* protection, established during the Manhattan Project.

Heavy water. Water that contains *deuterium atoms* in place of *hydrogen* atoms. Heavy water is used in the *Savannah River Site production reactors*.

Highly enriched uranium. *Uranium* with more than 20 percent of the *uranium 235* isotope, used for making nuclear weapons and also as *fuel* for some isotope-production, research, and power reactors. *Weapons-grade uranium* is a subset of this group.

High-level waste. Material generated by chemical *reprocessing* of *spent fuel* and *irradiated targets*. High-level waste contains highly *radioactive*, short-lived *fission products*, hazardous chemicals, and toxic heavy metals. High-level waste is usually found in the form of a liquid, a solid *saltcake*, a sludge, or a dry powdery *calcine*.

Hydrogen. The lightest element. Two of the three *isotopes* of hydrogen have been used in nuclear weapons: *deuterium* and *tritium*.

Idaho National Engineering Laboratory. An 893-square-mile Federal government-owned reservation in the eastern Idaho desert. The Idaho National Engineering Laboratory is the site of many research and test reactors and of the Idaho Chemical Processing Plant, where *spent nuclear fuel* from the U.S. Navy and from *research reactors* was *reprocessed*.

Inert gas. A gas that does not react chemically with other substances. The inert gases are helium, neon, argon, xenon, and radon. Also occasionally used inaccurately to refer to nitrogen.

Ionizing radiation. *Radiation* that is capable of breaking apart *molecules* or *atoms*. The splitting or *decay* of unstable *atoms* typically emits ionizing radiation.

Irradiate. To expose to *ionizing radiation*, usually in a *nuclear reactor*. *Targets* are irradiated to produce *isotopes*.

Isotopes. Different forms of the same chemical element that differ only by the number of *neutrons* in their *nucleus*. Most elements have more than one naturally occurring isotope. Many more isotopes have been produced in reactors and scientific laboratories.

K Reactor. A *plutonium* and *tritium production reactor* at the *Savannah River Site*, started in 1954 and shut down in 1988. The code name "K" is arbitrary.

K-25 Gaseous Diffusion Plant. The first full scale *gaseous diffusion* plant in the world, built in Oak Ridge, Tennessee, for the *Manhattan Project*. "K-25" is an arbitrary code name.

Lithium. The lightest metal, and the third lightest element. Lithium has two naturally occurring *isotopes*, lithium 6 and lithium 7. Lithium 6 *targets* are *irradiated* to manufacture *tritium*.

Los Alamos National Laboratory. The U. S. Government laboratory, established in 1943 as part of the *Manhattan Project*, that designed the first nuclear weapons. Located in northern New Mexico, about 60 miles north of Albuquerque.

Low-enriched uranium. *Uranium* that has been *enriched* until it consists of about 3 percent *uranium 235* and 97 percent *uranium 238*. Used as *nuclear reactor fuel*.

Low-level waste. A catchall term for any *radioactive* waste that is not *spent fuel*, *high-level*, or *transuranic waste*.

Manhattan Project. The U.S. Government project that produced the first nuclear weapons during World War II. Started in 1942, the Manhattan Project formally ended in 1946. The *Hanford Site*, the *Oak Ridge Reservation*, and the *Los Alamos National Laboratory* were created for this effort. Named for the Manhattan Engineering District of the U.S. Army Corps of Engineers.

Mined geologic disposal. See *geologic repository*.

Mixed waste. Waste that contains both chemically hazardous and *radioactive* materials.

Molecules. Larger structures formed by the bonding of *atoms*.

N Reactor. The last *production reactor* built at the *Hanford Site*. The N reactor operated from 1963 through 1987. The code name "N" is arbitrary.

National Environmental Policy Act. A Federal law, enacted in 1970, that requires the Federal government to consider the environmental impacts of, and alternatives to, major proposed actions in its decisionmaking processes. Commonly referred to by its acronym, NEPA.

Natural uranium. *Uranium* that has not been through the *enrichment* process. It is made of 99.3 percent *uranium 238* and 0.7 percent *uranium 235*.

Neutron. A massive, uncharged particle that comprises part of the *nucleus*. *Uranium* and *plutonium atoms fission* when they absorb neutrons.. The *chain reactions* that make *nuclear reactors* and weapons work thus depend on neutrons. Manmade elements can be manufactured by bombarding other elements with neutrons in *production reactors*.

Nevada Test Site. A 1,350-square-mile area of the southern Nevada desert that has been the site of most of the U.S. *underground* and *atmospheric tests* since it opened in 1951. The site is some 65 miles northwest of Las Vegas.

Nonproliferation. Efforts to prevent or slow the spread of nuclear weapons and the materials and technologies used to produce them.

Nuclear reactor. A device that sustains a controlled nuclear *fission chain reaction*.

Nuclear weapons complex. The chain of foundries, *uranium enrichment* plants, reactors, *chemical separation* plants, factories, laboratories, assembly plants, and test sites that produces nuclear weapons. There were 16 major facilities in the U.S. nuclear weapons complex, located in 12 states.

Nucleus. The clump of protons and *neutrons* at the center of an *atom* that determine its identity and chemical and nuclear properties.

Oak Ridge. A 58-square-mile reservation near Knoxville, Tennessee. Oak Ridge was established as part of the *Manhattan Project* in 1943 to produce *enriched uranium*. Today it is the location of *K-25* and *Y-12* plants and the Oak Ridge National Laboratory (which was initially referred to by the arbitrary code name, "X-10.").

Pad. A flat concrete or asphalt surface used for the temporary storage of wastes. Its purpose is to keep wastes from leaching into the soil.

Pantex Plant. The United States' *final assembly* plant for nuclear weapons, located in the Texas panhandle near Amarillo.

PCBs. A group of commercially produced organic chemicals used since the 1940s in industrial applications throughout the *nuclear weapons complex*. Most notably, PCBs are found in many of the gaskets and large electrical transformers and capacitors in the *gaseous diffusion plants*. PCBs have been proven to be toxic to both humans and laboratory animals. "PCB" is an abbreviation of the full name, "polychlorinated biphenyls."

Plutonium. A manmade *fissile* element. Pure plutonium is a silvery metal that is heavier than lead. Material rich in the plutonium 239 *isotope* is preferred for manufacturing nuclear weapons, although any plutonium can be used. Plutonium 239 has a *half-life* of 24,000 years.

Plutonium residues. Materials left over from the processing of *plutonium* that contain enough plutonium to make its recovery economically worthwhile.

Plutonium pit. A vernacular term that refers to the spherical core of a thermonuclear weapon. This pit is the "trigger" of the primary portion of the weapon that, when compressed, reaches a critical mass and begins a sustained nuclear fission chain reaction.

Production reactor. A *nuclear reactor* that is designed to produce manmade *isotopes*. *Tritium* and *plutonium* are made in production reactors. The United States has 14 such reactors: nine at the *Hanford Site* and five at the *Savannah River Site*. Some *research reactors* are also used to produce *isotopes*.

PUREX. An acronym for Plutonium-Uranium Extraction, the name of the chemical process usually used to *reprocess spent nuclear fuel* and *irradiated targets*. Also refers to the first plant at the *Hanford Site* built to use this process. The PUREX plant operated from 1956 to 1972 and from 1983 to 1988.

Radiation. Energy transferred through space or other media in the form of particles or waves. In this document, we refer to *ionizing radiation*, which is capable of breaking up *atoms* or *molecules*. The splitting, or *decay*, of unstable *atoms* emits ionizing radiation.

Radioactive. Of, caused by, or exhibiting *radioactivity*.

Radioactivity. The spontaneous emission of *radiation* from the *nucleus* of an *atom*. *Radionuclides* lose particles and energy through the process of *radioactive decay*.

Radionuclide. A *radioactive* species of an *atom*. For example, *tritium* and *strontium 90 are* radionuclides of elements hydrogen and strontium.

Radon. A radioactive *inert gas* that is formed by the decay of radium. Radium is, in turn, a link in the decay chain of *uranium 238*. Radon, which occurs naturally in many minerals, is the chief hazard of *uranium mill tailings*.

Reprocessing. Synonymous with *chemical separation.*

Research reactor. A class of *nuclear reactors* used to do research into nuclear physics, reactor materials and design, and nuclear medicine. Some research reactors also produce *isotopes* for industrial and medical use.

Resource Conservation and Recovery Act (RCRA). A Federal law enacted in 1976 to address the treatment, storage, and disposal of hazardous waste.

Rocky Flats Plant. *Plutonium* processing and manufacturing plant located 21 miles northwest of Denver, Colorado. Rocky Flats made the plutonium triggers of nuclear weapons. Started operations in 1951. Now called the Rocky Flats Environmental Technology Site.

Saltcake. A cake of dry crystals of nuclear waste found in *high-level-waste* tanks.

Saltstone. A concrete-like material made with *low-level radioactive waste*.

Savannah River Site. A *plutonium* and *tritium* production site, established in 1950, covering 300 square miles along the Savannah River in South Carolina, near Augusta, Georgia. Five *production reactors* and two *chemical separation plants* are located here.

Shielding. Material used to block or absorb *radiation*. Often placed between sources of radiation and people or the environment.

Spent nuclear fuel. *Fuel elements* and *targets* that have been *irradiated* in a nuclear reactor.

Strontium. An element. *Isotope* strontium 90 is one of the most common *fission products*. It has a *half-life* of about 30 years. Strontium is chemically similar to calcium.

Superfund. A term commonly used to refer to the *Comprehensive Environmental Response, Compensation and Liability Act*.

Target. Material placed in a *nuclear reactor* to be bombarded with *neutrons*. This is done to produce new, manmade *radioactive* materials. Most important, targets of *uranium 238* are used to make *plutonium*, and targets of *lithium* are used to make *tritium*.

Thermonuclear weapon. A nuclear weapon that uses *fission* to start a *fusion* reaction. Commonly called hydrogen bomb or "H-bomb."

Thorium. An element. Thorium is a byproduct of the *decay* of *uranium*.

Toxic Substances Control Act. A Federal law, enacted in 1976 to protect human health and the environment from unreasonable risk caused by exposure to or the manufacturing, distribution, use, or disposal of substances containing toxic chemicals.

Transport cask. A container used to transport *spent nuclear fuel* and other *radioactive* materials. Its purpose is to shield people from radiation while it is transported.

Transuranic elements. All elements beyond *uranium* on the periodic table. All of the transuranic elements are manmade.

Transuranic waste. Waste contaminated with *uranium 233* or *transuranic elements* having *half-lives* of over 20 years in concentrations of more than 1 ten-millionth of a *curie* of per gram of waste.

Tritium. The heaviest *isotope* of the element *hydrogen*. Tritium is three times heavier than ordinary hydrogen. Tritium gas is used to boost the explosive power of most modern nuclear weapons, inspiring the term, "hydrogen bomb." It is produced in *production reactors* and has a *half-life* of just over 12 years.

Tritium Facility. A plant at the *Savannah River Site* where *tritium* is separated from *lithium targets* and placed in capsules that are part of nuclear weapons.

Underground testing. Testing of a nuclear device or its effects by exploding it underground.

Uranium. The basic material for nuclear technology. It is a slightly *radioactive* naturally occurring heavy metal that is more dense than lead. Uranium is 40 times more common than silver.

Uranium hexafluoride. A gaseous form of *uranium* used in the *gaseous-diffusion enrichment* process.

Uranium mill. A plant where *uranium* is separated from ore taken from mines.

Uranium-mill tailings. The sandlike materials left over from the separation of *uranium* from its ore. More than 99 percent of the ore becomes tailings.

Uranium Mill Tailings Remedial Action Program. A program to reduce the hazards posed to the public by *uranium mill tailings*. The program was created by a Federal law passed in 1978. The *Department of Energy*'s *Office of Environmental Management* is responsible for carrying its implementation. Often referred to by its acronym, "UMTRA."

Uranium 233. A manmade *fissile isotope* of *uranium*.

Uranium 235. The lighter of the two main *isotopes* of *uranium*. Uranium 235 makes up less than 1 percent of the uranium that is mined from the ground. It has a *half-life* of 714 million years. Uranium 235 is the only naturally occurring *fissile* element.

Uranium 238. The heavier of the two main *isotopes* of *uranium*. Uranium 238 makes up over 99 percent of uranium as it is mined from the ground. It has a *half-life* of 4.5 billion years. It is not easily split by *neutrons*.

Vitrification. A process that stabilizes nuclear waste by mixing it with molten glass. The glass is poured into metal canisters, where it hardens into logs. Plants for vitrifying *high-level-waste* have been built in the United States at *West Valley*, New York, and the *Savannah River Site*.

Waste Isolation Pilot Plant. A *geologic repository* intended to provide permanent disposal deep underground for *transuranic wastes*. Located 2,150 feet underground in a salt bed near Carlsbad, New Mexico.

Weapons-grade uranium. *Uranium* made up of over 90 percent of the *fissile uranium 235 isotope*.

Weldon Spring. Named for a town near St. Louis, Missouri, the Weldon Spring plant first performed many of the same *uranium* processing operations as the *Fernald plant*. The Weldon Spring plant operated from 1957 to 1966.

West Valley Demonstration Project. A plant near Buffalo, New York, used to demonstrate the *reprocessing* of *spent nuclear fuel* from commercial nuclear power plants. West Valley operated from 1966 to 1972. A *vitrification* plant for *high-level waste* has been built at the site.

Yellowcake. A common *uranium* compound, named for its typical color. Uranium is sent from the *uranium mill* to the refinery in this form.

Yucca Mountain. A site on, and adjacent to, the *Nevada Test Site* that is being examined to determine whether it is suitable for use as a *geologic repository* for the Department's *high-level wastes* and *spent fuel* from commercial nuclear reactors.

Y-12. A plant in *Oak Ridge*, Tennessee, built for the *Manhattan Project* to *enrich uranium* using *calutrons*. Today, this plant produces and stores components made of *enriched* and *depleted*

This granite block marks the location of buried radioactive materials that include wastes from Enrico Fermi's uranium-graphite pile, built for the Manhattan Project in 1942 under the University of Chicago's Stagg Field, then relocated to this area. The Fermi pile demonstrated the world's first man-made self-sustaining nuclear chain reaction. The caption on the marker reads: "CAUTION - DO NOT DIG Buried in this area is radioactive material from nuclear research conducted here 1943-1949. Burial area is marked by six corner markers 100 ft. from this center point. There is no danger to visitors. U.S. Department of Energy 1978." *Plot M, Palos Park Forest Preserve, Cook County Forest Preserve District, 20 miles southwest of Chicago, Illinois. November 5, 1995.*

93